

III. *Discoveries on the Sex of Bees, explaining the Manner in which their Species is propagated; with an Account of the Utility that may be derived from those Discoveries by the actual Application of them to Practice.* By Mr. John Debraw, Apothecary to Addenbrook's Hospital at Cambridge, and Member of an Oeconomical Society in the Principality of Liege in Westphalia. Communicated by the Rev. Nevil Maskelyne, B. D. F. R. S. and Astronomer Royal.

Read Nov. 21, 1776. **T**HE republic of bees has at all times gained universal esteem and admiration: their culture, an object so worthy of our attention, has attracted and still does engage that of many of the learned, and has arrived at a considerable degree of improvement of late years; but their mode of propagating their species seems to this day to have baffled the ingenuity of ages in their attempts to discover it. The most skilful naturalists have been strangely misled in their opinion, that the bees, as well as the other tribes of animals, are perpetuated by copulation; though they acknowledge

acknowledge that they have never been able to detect them in the act.

PLINY, who was likewise of the same opinion, that in this particular they do not differ from other animals, observes, "*Apium coitus visus est nunquam.*" SWAMMERDAM, that sagacious observer, having never been able to discover it, entertained a notion, that the female or queen bee was fecundated without copulation; that it was sufficient for her to be near the males; that a vivifying *aura*, exhaling from the body of the males, and absorbed by the female, might impregnate her eggs. At last the incomparable REAUMUR thought he had in a great measure removed the veil, and brought their manner of generating nearly to a proof. This part of physics has been the principal object of my researches for several years past, having been insensibly engaged in it by the pleasure I took in so curious an inquiry; and although this pursuit has been attended with more difficulties and embarrassments than can be well imagined, I have not been discouraged, and have carefully avoided launching into conjectures. To introduce a new system in the doctrine of bees, which in a great measure contradicts all former received opinions, requires, previous to its appearance, every sanction the various experiments, successfully repeated, can possibly give it. The results of those experiments,

ménts, made all in glass-hives, which carry with them an entire évidence, afford sufficient reasons to assert, that bees belong to that class of animals among which, although they have sexes, a true copulation cannot be proved; and that their *ova*, like the spawn of fishes, most probably owe their fecundation to an impregnation from the males, as will appear in the sequel of this narrative.

I am not a little pleased to find that the celebrated MARALDI had such a notion, and I lament his neglecting to confirm it. He says, in his *Observations upon Bees*, in the History of the Academy of Sciences for the year 1712, p. 332: *Nous n'avons pu découvrir jusqu' à présent de quelle maniere se fait cette fécondation, si c'est dans le corps de la femelle, ou bien si c'est à la maniere des poissons, après que la femelle a posé ses œufs: la matiere blanchâtre dont l'œuf est environné au fond de l'alvéole peu de temps après sa naissance, semble conforme à la derniere opinion, aussi bien que les remarques faites plusieurs fois d'un grand nombre d'œufs qui sont restés inféconds au fond de l'alvéole autour desquels nous n'avons point vu cette matiere.* “ We never yet were able to discover in what manner “ this fecundation is performed; whether it is in the body “ of the female, or whether it is after the manner of “ fishes, after the female or queen-bee has deposited “ her eggs: that liquid whitish substance, with which “ each

“ each egg is furrounded at the bottom of the cell a
 “ little while after its being laid, seemingly establisning
 “ this last opinion, as well as the frequent remarks made
 “ of a great number of eggs remaining barren in the cell,
 “ round which we could not see the above-mentioned
 “ whitish substance.”

This ingenious naturalist, by a nice examination of the structure of the drones, had, as well as SWAMMERDAM, discovered some resemblances to the male organs of generation; and from thence conjectured, they were the males of the bee-insect; but he owns, with the rest, that he never could discover them in the act of copulation.

Having stood the trials of so many prying eyes in every age, the bees, as has been observed by an ingenious author, had gained the character of an inviolable chastity, till REAUMUR blasted their reputation. He makes the queen no better than a MESSALINA^(a); though he could see no more than what would raise a mere jealousy or generate suspicions.

In order to be the better understood in the relation of my own experiments on the fecundation of bees, I here premise the outlines of the opinions adopted by the above-mentioned naturalists on that head. They assert that the

[a] Vid. JUVENAL, Sat. vi. ver. 128.

queen is the only female in the hive, and the mother of the next generation; that the drones are the males by which she is fecundated; and that the working bees, or bees that collect wax on the flowers, that knead it and form from it the combs and cells which they afterwards fill with honey, are of neither sex.

But of late Mr. SCHIRACH, a German naturalist, has given us a very different view of the classes that constitute the republic of bees, in an ingenious publication in his own language, under the title of *The Natural History of the Queen of the Bees*, which has been since translated into French; an account of which has been given in the Monthly Review, from which I beg leave to relate the author's doctrine with regard to the working-bees only; the quality and functions of the drones being points which do not appear to be yet settled by Mr. SCHIRACH himself. He affirms, that all the common bees are females in disguise, in which the organs that distinguish the sex, and particularly the *ovaria*, are obliterated, or at least, through their excessive minuteness, have not yet been observed: that every one of those bees in the earlier period of its existence is capable of becoming a queen-bee, if the whole community should think proper to nurse it in a particular manner, and raise it to that rank. In

short, that the queen-bee lays only two kinds of eggs; *viz.* those that are to produce the drones, and those from which the working-bees are to proceed.

The trials made by Mr. SCHIRACH seem to evince the truth of his conclusions in the most satisfactory manner, singular as they appear to be at first sight; and indeed in my own judgement, from the constant happy result of my numerous experiments, which I began near two years before Mr. SCHIRACH's publication, and repeated every season since. I am enabled to pronounce on their reality.

Chance I own befriended me in that discovery, whilst I was most anxiously endeavouring to ascertain the use of drones. It was in the spring of the year 1770, that I for the first time discovered what MARALDI had only conjectured, I mean the impregnation of the eggs by the males, and that I was made acquainted with the difference of size in the drones or males observed by MARALDI in his *Observations upon Bees*, inserted in the History of the Royal Academy of Sciences for the year 1712, p. 333. in these words:

Nous avons trouvé depuis peu une grande quantité de bourdons, beaucoup plus petits que ceux que nous avions remarqué auparavant, et qui ne surpassent point la grandeur des petites abeilles; de sorte qu'il n'auroit pas été aisé
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de les distinguer dans cette ruche de abeilles ordinaires, sans le grand nombre que nous y en avons trouvé. Il se pourroit bien faire que dans les ruches où l'on n'a pas trouvé de gros bourdons, il y en eût de ces petits, et qu'ils y aient été confondus avec le reste des abeilles, lorsque nous ne savions pas encore qu'il y en eût de cette taille. “ We have of

“ late found a great quantity of drones much smaller
“ than those we had formerly observed, and which do not
“ exceed in size the common bees; so that it would not
“ have been easy to distinguish them in that hive from
“ the common bees, had not the quantity of them been
“ very considerable. It might certainly have happened
“ that in those hives, where we have not been able to
“ discover large drones, there were a great number of
“ those little ones, which may have been intermixed
“ among common bees when we were yet ignorant that
“ any such small drones were existing.”

REAUMUR himself, p. 591. of his *Natural History of Insects*, says, “ We have likewise found drones that were
“ no bigger than the common bees.”

They have notwithstanding escaped the observation of Mr. SCHIRACH, and of his friend Mr. HATTORF member of an Academy in Lusatia, who, in a memoir he presented in the year 1769, annihilates entirely the use of drones in a hive; and advances this singular
opinion,

opinion, that the queen-bee of a hive lays eggs which produce youngones, without having any communication with the drones. For what purpose should wife nature then have furnished the drones with that large quantity of feminal liquor? To what use so large an apparatus of fecundating organs, so well described by REAUMUR and MARALDI?

But I beg leave to remark, that those gentlemen seem to have drawn too hasty conclusions from their experiments, in rejecting the drones as bearing no share in the propagation of those insects. Their observations, that hives are peopled at a time of the year when there are no drones in being, is no ways conclusive; as it is evident, that they had seen none but drones of a large size, their silence on the difference in the size of them justifying my remark. But to resume the narrative of my experiments: I had watched my glass-hives^(b) with indefatigable attention from the moment the bees, among which I had taken care to leave a large number of drones, were put into them, to the time of the queen laying her eggs, which generally happens the fourth or fifth day. I observed the first or second day (always before the third) from the time the eggs are placed in the cells, that a great number

(b) Glass-hives were used in preference to boxes, for a purpose too obvious to need explaining.

of bees, fastening themselves to one another, hung down in the form of a curtain from the top to the bottom of the hive, in a similar manner they had done before at the time the queen deposited her eggs; an operation which (if we may conjecture at the instincts of insects) seems contrived to hide what is transacting: be that as it will, it answered the purpose of informing me that something was going forward. In fact, I presently after perceived several bees, the size of which through this thick veil (if I may so express myself) I could not rightly distinguish, inserting the posterior part of their bodies each into a cell, and sinking into it, where they continued but a little while. After they had retired, I saw plainly with the naked eye a small quantity of a whitish liquor left in the angle of the basis of each cell, containing an egg: it was less liquid than honey, and had no sweet taste at all. Within a day after, I found this liquor absorbed into the embryo, which on the fourth day is converted into a small worm, to which the working-bees bring a little honey for nourishment, during the first eight or ten days after its birth. After that time they cease to feed them; for they shut up the cells, where these embryos continue inclosed for ten days more, during which time they undergo various changes too tedious here to describe.

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To evince the reality of this observation, and to prove that the eggs are fecundated by the males, and that their presence is necessary at the time of breeding, I proceeded to the next experiments. They consisted in leaving in a hive the queen with only the common bees, without any drones, to see whether the eggs she laid would be prolific. I accordingly took a swarm, shook all the bees into a tub of water, and left them in it till they were quite senseless, which gave me an opportunity to distinguish the drones without any danger of being stung. After I had recovered the working-bees and their queen from the state they were in, by spreading them on brown paper in the sun, I replaced them in a glass-hive, where they soon began to work as usual: the queen laid eggs, which I little suspected to be impregnated, as I thought I had separated all the drones or males, and therefore omitted watching the bees; but at the end of twenty days (the usual time of their hatching) I found to my surprise some of the eggs hatched into bees, others withered away, and several of them covered with honey. I immediately inferred that some of the males, having escaped my notice, had impregnated only part of the eggs; but, in order to convince myself of the truth of my supposition, I thought it necessary to take away all the brood-comb that was in the hive, in order to oblige

the bees to provide a fresh quantity, being fully determined to watch narrowly their motions after new eggs should be deposited in the cells. This was done accordingly, and at last the mystery was unravelled. On the second day after the eggs were placed in the cells, I perceived the same operation which I have related in a former experiment; I mean, the bees hung down in the form of a curtain, while others thrust the posterior part of their body into the cells: I then introduced my hand into the hive, broke off a piece of the comb containing two of those insects, and kept them for examination. I found in neither of them any sting (a circumstance peculiar to drones only) and upon dissection, by the help of a DOLLOND's microscope, discovered in them the four cylindrical bodies, which contain the glutinous liquor of a whitish colour, observed by MARALDI in the large drones.

Having till then never observed any difference in the size of drones, I immediately perused the Memoirs on Bees published by Mess. MARALDI and REAUMUR, and found that they had remarked it frequently. I have inserted in a preceding page the substance of their observations on that head, as taken from their writings. The reason of that difference must I doubt be placed amongst other *arcana* of nature. I found myself therefore under a necessity in my next experiments to be more particular

in destroying the males, even those which might be suspected to be such.

I once more immersed all the same bees in water; and, when they appeared to be in a senseless state, I gently pressed every one of them between my fingers, in order to distinguish those armed with stings from those that had none, which last I might suspect to be males. Of these I found fifty-seven, exactly of the size of common bees, yielding a little whitish liquor on being pressed between the fingers. I killed every one, and replaced the swarm in a glass-hive, where they immediately applied again to the work of making cells; and on the fourth or fifth day, very early in the morning, I had the pleasure to see the queen-bee depositing her eggs in those cells, which she did by placing the posterior part of her body in each of them. I continued on the watch most part of the ensuing days, but could discover nothing of what I had seen before.

The eggs, after the fourth day, instead of changing in the manner of caterpillars, were found in the same state they were in the first day, except that some of them were covered with honey. But a very singular event happened the next day about noon: all the bees left their own hive, and were seen attempting to get into a neighbouring common hive, on the stool of which I found their queen dead,

having no doubt been slain in the engagement. The manner in which I account for this event is as follows: the great desire of perpetuating their species, which is most observable in these insects, and to which end the concurrence of the males seems so absolutely necessary, made them desert their own habitation where no males were left, in order to fix their residence in a new one, in which, there being a good stock of males, they might the better accomplish their purpose. If this does not yet establish the reader's faith of the necessity of the males bearing a share in the fecundation of the *ova*, the next experiment cannot I presume fail to convince him.

I took the brood-comb which, as I observed before, had not been impregnated; I divided it into two parts; one I placed under a glass-bell N° 1. with honey-comb for the bees' food; I took care to leave a queen, but no drones, among the common bees I confined in it. The other piece of brood-comb I placed under another glass-bell N° 2. with a few drones, a queen, and a number of common bees proportioned to the size of the glass; the rest I disposed of as before. The result was, that in the glass N° 1. no impregnation happened; the eggs remained in the same state they were in when put into the glass; and, upon giving the bees their liberty on the seventh day, they all flew away, as was found to be the case in the for-

mer experiment: whereas in the glass N° 2. I saw, the very day after the bees had been put under it, the impregnation of the eggs by the drones in every cell containing eggs; the bees did not leave their hive on receiving their liberty; and, in the course of twenty days, every egg underwent all the above-mentioned necessary changes, and formed a pretty numerous young colony, in which I was not a little startled to find two queens.

Fully satisfied concerning the impregnation of the eggs by the males, I desisted for the present from any further experiments on that head, being exceedingly anxious to endeavour to account for the presence of this new queen.

I conjectured that either two queens, instead of one, must have been left among the bees I had placed under that glass; or else that the bees could, by some particular means of their own, transform a common subject into a queen.

In order to put this to the test, I repeated the experiment with some variation. I got four glass-hives blown flat, which I thought preferable to the bell-shaped ones I had used before, as I could with those better examine what was going forward. I took a large brood-comb from an old hive, and, after having divided it into several pieces, I put some of them, containing eggs, worms, and nymphs, with food, *viz.* honey &c. under each of the glasses;

glaffes; and confined within each a fufficient number of common bees, among which I left fome drones, but took care that there fhould be no queen.

The bees finding themfelves without a queen, made a ftrange buzzing noife, which lafted near two days; at the end of which they fettled and betook themfelves to work: on the fourth day I perceived in each hive the beginning of a royal cell, *a certain indication that one of the inclofed worms would foon be converted into a queen.* The conftruction of the royal cell being nearly accomplifhed, I ventured to leave an opening for the bees to get out, and found that they returned as regularly as they do in common hives, and fhewed no inclination to defer their habitation. But, to be brief, at the end of twenty days, I obferved four young queens among the new progeny.

On relating the refult of thefe experiments to a member of this univerfity, well converfant in the natural hiftory of bees, he deemed it neceffary, that they fhould be repeated, in order the better to eftablifh the truth of a fact feemingly fo improbable, that the eggs deftined by nature to produce neutral or common bees, fhould be transformed into females or queens. He started an objection to me, which by the publication of Mr. SCHIRACH appearing a little time after, feems to have been pointed out to that author alfo by Mr. WITHELMI, his

his brother-in-law, namely, that the queen-bee of a hive, besides the eggs which she deposits in the royal cells, might also have laid royal or female eggs either in the common cells, or indiscriminately throughout the different parts of the hive. He further supposed, that in the pieces of brood-comb, which had been successfully employed in the last experiments for the production of a queen, it had constantly happened, that one or more of these royal eggs, or rather the worms proceeding from them, had been contained.

But the force of his objection was removed soon after by the same success having attended a number of other experiments which I since made, an account of which would take up too much room here; and this gentleman, together with Mr. SCHIRACH's brother-in-law, was at last brought to admit, that the working-bees are invested with a power of raising a common subject to the throne, when the community stands in need of a queen; and that accordingly every worm of the hive is capable, under certain circumstances, of becoming the mother of a generation: that it owes its metamorphosis into a queen, partly to the extraordinary size of the cell, and its particular position in it; but principally to a certain nourishment appropriated to the occasion, and carefully administered to it by the working-bees while it is in the worm-state,

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by which, and possibly other means as yet unknown, the development and expansion of the germ of the female organs, previously existing in the embryos, is effected, and those differences in its form and size are produced, which afterwards so remarkably distinguish the queen from the common working-bees. And finally it appears evident, from the experiments made by Mr. SCHIRACH and myself, that the received opinion, that the queen lays a particular kind of eggs, appropriated to the production of other queens, is erroneous. I am not a little flattered with the similarity of my discoveries with those of the ingenious German naturalist, in proving the sex of the common bees: although we so widely differ in what relates to the use of the males, whom, as we have seen before, he imagines to be quite useless. I am also not a little pleased to find, that our experiments on the production of a queen from a common embryo agree so well.

I shall now beg leave to point out the advantage that may accrue to the public from these observations, which is that of forming artificial swarms or new colonies; or in other words, of furnishing the means to bring on a numerous increase of those useful insects: an object of some importance to this kingdom, as being the only means to prevent the annual exportation of considerable sums in the purchase of wax, a great quantity
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of which is lost every season for want of keeping up a sufficient stock of bees to collect it.

The practice of this new art, Mr. SCHIRACH tells us, has already extended itself through Upper Lusatia, the Palatinate, Bohemia, Bavaria, Silesia, and even in Poland. In some of those countries it has excited the attention and patronage of government; and even the Empress of Russia has thought it of such importance, that she has sent a person to Klein Bautzen, to be instructed in the general principles, and learn all the *minutiae* of this new art.

The narrow limits of this paper do not permit me here to give an account of Mr. SCHIRACH's ingenious observations. I beg leave to refer the curious reader to the work itself, which, with the reviewers, I wish was translated into the English language, as it contains many particulars highly deserving the notice of the speculative naturalist, as well as of those who cultivate bees either for profit or amusement.

